UNITED PLANTERS' ASSOCIATION OF SOUTHERN INDIA SCIENTIFIC DEPARTMENT BULLETIN

OBSERVATIONS
ON
HELOPELTIS (TEA MOSQUITO BLIGHT)
FOR
SOUTH INDIAN TEA PLANTERS

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TABLE II

Month	Maximum temperature		Minimum temperature		Rainfall	
	Dooars	Munja-mallai	Dooars	Munja-mallai	Dooars	Munja-mallai
January	72·0	72·2	50·8	58·8	0·43	1·27
February ...	76·5	76·2	52·8	58·2	1·54	...
March	84·8	83·4	59·7	61·5	2·54	1·89
April	89·5	94·8	68·2	66·2	8·30	3·37
May	88·3	84·7	72·3	63·6	22·31	5·06
June	87·9	79·6	75·2	65·0	42·14	39·30
July	88·2	75·9	76·8	62·3	44·96	21·21
August	88·1	82·0	76·7	63·0	31·82	7·48
September ...	87·2	72·9	75·3	61·1	26·4	3·44
October	85·8	76·8	69·8	61·2	5·9	11·22
November ...	81·3	69·2	60·7	60·1	0·27	7·27
December ...	75·2	70·3	52·9	59·1	0·14	3·09

From a glance at this table we find that in North India from April to September the highest maximum temperature coincides with the highest minimum temperature and highest rainfall, and it is easily conceivable that as humidity and temperature are the controlling factors in the development of Helopeltis that during the months mentioned Helopeltis should be at the height of its development. The eggs would hatch at a more rapid pace and the development of the insect generally would take place more rapidly. The minimum temperature would seem to be the limiting factor in the development of Helopeltis in North India, for, after the month of October there is a sudden drop in the average minimum temperature—69·8° to 52·9° in December —a difference of 17°, at which period the insect has apparently abandoned its host, and its development come to a standstill. In contrast to this, in South India, the average minimum temperature is practically constant throughout the year, ranging round about 62°F., and as the attacks of Helopeltis are present throughout the year to varying degrees, the

minimum temperature cannot be regarded as the limiting factor such as is the case in North India. This constant feature of the minimum temperature possibly explains the fact of the non-disappearance of the pest throughout the year in South India, whereas in North India the months of December, January and February are practically free.

One further point in the effect of climate in the varying development of Helopeltis in North India and South India must bear mentioning, viz., the combined effect of rainfall and temperature. In North India, as stated, maximum rainfall is also accompanied by the maximum temperature and humidity. In South India, as a glance at the table will show, the temperature rises from February to May, and this is succeeded by a drop in temperature with the inception of the South-West Monsoon. Thus we have a cold period again entering combined with heavy rains with the result that there is a temporary lapse in the development of the pest during the monsoon months, followed by an increased vigour in the months following the monsoon, when the temperature again rises and the rainfall decreases. The effect of heavy rain on Helopeltis must also have an eliminating result on the presence of the pest. The effect of the heavy rain in the Dooars is no doubt partially balanced by the presence of all the factors more conducive to the most rapid development of the pest, so that the decrease in numbers of Helopeltis is more than compensated for by the more rapid hatching of the egg and development of the insect. In South Travancore, it is stated that the month of July, the mid-monsoon month seems to be the worst month for the attacks of Helopeltis.

From a consideration of the conditions encouraging an attack of the pest and those militating

against an attack, and from the data given in the table concerning the climatic conditions experienced in South India, we should expect the attack to vary in the following manner :—

January February	Temperature comparatively low, cold nights, little rainfall.	Helopeltis present. Ravages negligible.
March April May.	Temperature gradually increasing, less cold nights, increased rainfall and increased humidity.	Attacks gradually become more perceptible and in May much damage to crops may be done.
June July	Temperature decreases combined with heavy downpours of rain.	Attacks held up owing to uncongenial conditions, but still noticeable.
August	Slight decrease in amount of rain, temperature high.	Attacks begin to increase.
September October	Increase in temperature, comparatively light rains.	Attacks increase to critical point once more.
November December	Temperature decreasing, cold nights occur.	Attacks gradually become negligible once more.

Naturally, the degree of attack cannot always be stated to be constant for any one month, but generally it may be assumed that in South India the intensity of attack reaches two maxima. Thus we find one maximum reached in April, May, and another in September, October, with a dip in the course during June, July. It is necessary to remark here that in South Travancore, it is stated that the attacks of Helopeltis are felt worst in the month of July. This fact cannot be relegated entirely to Helopeltis, for it must be borne in mind that the month of July is also the worst flushing month in the year. There cannot be any doubt but that the intensity of attack does decrease, but this decrease coinciding with the heaviest decrease in the flushing capabilities of the tea, would naturally make it appear from a consideration of the crop yield during the month of July, that the intensity of attack of Helopeltis is worst during the month of July. In

considering the intensity of attack it is absolutely essential at the same time to consider the flushing capacity of the bushes. In North India, the intensity of attack commences practically at zero during the cold months, increasing up to a maximum in August and decreasing once again with the incoming cold weather.

It is interesting to note that the degree of intensity of attack varies in exactly the same manner as the monthly crop figures, whether considered in relation to North India or South India. To take figures for the monthly crop figures on South Indian Estates we have the following :—

TABLE III

Months	Estate A	B	C	D	E	F
January	4·5	5·6	5·4	3·6	6·12	4·72
February	4·7	5·8	5·7	3·3	4·68	6·91
March	4·1	4·3	4·2	3·2	8·64	9·56
April	6·7	5·4	10·5	8·1	11·31	9·49
May	10·1	5·7	14·1	12·8	12·51	13·94
June	6·4	7·4	4·9	5·9	6·11	8·35
July	8·8	8·2	5·1	8·7	4·33	2·09
August	10·0	13·6	5·2	6·7	1·55	5·38
September	13·8	16·4	10·5	14·2	13·24	8·79
October	11·7	11·4	12·8	11·6	13·37	11·53
November	11·2	8·8	11·4	12·6	10·69	10·64
December	8·0	7·2	10·2	9·3	7·43	8·59

It will be seen that the crop yields reach two maximum points during the year, namely, in April, May, and September, October, November. In other words, we have during these months conditions most suitable for the flushing of the tea bushes, viz., high humidity and heat. Unfortunately, the same conditions favour the development of Helopeltis and one would expect the ravages of the pest to be prominent simultaneously with the months of highest yielding. Actual figures of the extent of damage caused by Helopeltis throughout the year

are not available, but from observations made by Planters, it would seem that April, May, and September, October and November are the two periods when the damage caused by Helopeltis reaches a maximum, with the exception of South Travancore, where it is claimed that July produces the maximum damage.

To revert to the period of hatching of the egg.—It will be clear, from the North Indian figures, and from ordinary deduction, that during the months of April-May and September-October we have the optimum conditions for the hatching of eggs. One would expect therefore the egg to hatch during a period of six or seven days. An experiment carried out by the Manager of the Munjamullai Estate showed this to be the case, and this period was accepted for the purpose of the calcium cyanide experiments (q. v.).

Larvæ.—The larvæ emerge from the eggs as small reddish, wingless, insects, very much resembling an ant possessing a sting. (See Fig. 2.) It is capable of immediately commencing to feed on the young and tender leaves of the bush. In fact, observations made seem to show that most of the damage to the young buds, and incidentally to the crop, is caused by larvæ. This may be readily noted owing to the ease with which larvæ punctures in the leaf may be distinguished from punctures made by the adult insects. (See Fig. 1.) From the larval stage to the adult stage the insect undergoes five definite moults, with the following developments :—

Larval stage	....	No wings.
1st Moult.	....	Wings non-existent.
2nd ,,	....	Non-functional and extremely immature wings developed.
3rd Moult	....	Wings more developed.
4th ,,	....	Still further developed.
5th ,,	....	Functional wings. Adult stage.

These functional wings are only capable of propelling the insects very sluggishly. During the moulting stages the colour of the insect changes from red, though a greenish colour, to the adult, multi-coloured insect. Again climatic conditions regulate the speed with which the insect proceeds through these moults to maturity, the times observed in Assam being as follows :—

TABLE IV

Month		Time taken: For larva to attain maturity
January	...	36 days
February	...	24 ,,
March	...	15 ,,
April	...	12 ,,
May	...	12 ,,
June	...	9 ,,
July	...	9 ,,
August	...	9 ,,
September	...	12 ,,
October	...	15 ,,
November	...	24 ,,
December	...	30 ,,

Again we may conjecture that the insect in South India reaches maturity at the most rapid rate during the months of April, May and September, October.

Adult.—(See Figs. 3, and 4, Sketched from Andrews' Monograph on Helopeltis.) Many variations in colour and external characteristics may be observed in the adult insects. It is a small insect, length ¼"–3/8", usually with a brown hump between the thorax and a light green body. The male insect is considerably smaller than the female, the latter

developing with formation of eggs till it loses its light green colour and becomes almost completely white. Distinction between the male and female is also possible by an examination of the genital organs, the female being characterized by its ovipositor, which curls under its abdomen towards its head. (See Fig. 3.) The female is capable of laying eggs almost immediately after copulation, and this may take place two days after the attainment of the adult stage. The eggs may be deposited in almost any position in the bush from the red wood upwards, but as far as observations were made in Central Travancore, the base of the midribs of the younger leaves would seem to be the favourite place.

The female may continue to deposit eggs for two months or more, and since, during favourable climatic conditions the period lapsing between egg deposition and maturity is fifteen days, it will be obvious that a number of generations derived from a single insect may be capable of reproduction simultaneously. Andrews in his monograph on Helopeltis has given an account to illustrate the overlapping of the generations, and the following is an abstract :—

' . . . an attempt has been made to show the effect of this overlapping in the development of the insect throughout the year. The 1st of April has been selected as a point *d' appui* and it has been supposed that a female commenced to lay eggs on that date. Those eggs hatch, at that time of year, in about nine days, so that young forms will have emerged from the eggs first laid by the 10th of April. The young forms take about twelve days to become adult, so that by April 21st or 22nd the first adults of the first generation will have appeared and by the 24th eggs of the second generation will be deposited. The original female, however, continues, in the absence of disturbing factors, to lay eggs for two

months or more. Two months has been selected as the period for which oviposition is going on. Thus the original female will be depositing eggs until the end of May. These eggs will take about six days to hatch, and the young will take about nine days to reach maturity, two days after which the newly emerged females may be laying eggs, so that by June 17th the female from the eggs last laid by the original female will have commenced oviposition. Since they may continue to lay eggs for two months the deposition of eggs which will give rise to the second generation will continue until August 17th. Thus, the period during which eggs which will give rise to the second generation are being deposited extends from April 21st to August 17th, a period of four months. Applying a similar reasoning to the behaviour of the insects of the second generation, it is found that eggs which will give rise to the third generation will be deposited between May 16th and November 4th, or thereabouts, a period of five and a half months. Similarly, eggs which will give rise to the insects of the fourth generation will be deposited between June 7th and February 14th of the following year, or thereabouts, a period of eight months. The eggs laid as late as February 14th will not become adult until towards the end of March, which brings us to the time of year at which we started, viz., April 1st and taking into account the known fact that two months is not the maximum period for which oviposition can continue, it will be seen that four generations of the insect suffice to carry it through the year.

At the same time, the earliest individuals of the fourth generation have commenced to lay eggs by June 24th which will give rise to adults which are again laying eggs by July 13th, and it will be readily seen that while four generations can carry the insect over from the beginning of April to the

end of March, it is possible for it to have attained to the fourteenth generation by that time, and if we consider the insects which may be present on, say, August 15th, we find that there may be eggs, larvæ, and adults of all generations from the second to the sixth, together with eggs and larvæ of the seventh and perhaps a few remaining adults of the first. Thus it comes about that the four generation cycle of the pest becomes entirely obliterated, and on any day of the year the insect can be found in all stages. This is a matter of considerable importance from the point of view of control. It means, in the first place, that any artificial means of control, to be thoroughly effective, must be such that it will deal with the adults, larvæ, and the eggs at the same time, and it means, in the second place, that if any one stage is particularly resistant to adverse conditions that stage is always there to carry on, while any stage which is able to take advantage of any sudden turn in the insects' favour can also relied upon to be there.'

The two points worthy of note from the point of view of control are :—

(I) that at any one time we have the pest present in all stages of development from the egg to the adult and hence for effective artificial control, it is necessary to have some agency capable of dealing with the egg, larva, and adult.

(II) The large numbers of insects which may be produced within a given time. Leefman, as reported by Ashplant, has stated that the damage done by one insect and its related successive generations may accomplish damage to the extent of six thousand million pounds of tea leaf in six months. We have, however, something more to thank than 'infantile mortality' for such a state of affairs not existing. Unfavourable climatic conditions exert an influence

but from the control point of view, the possibility of parasitism on Helopeltis is at once suggested, either entomogenous or of a hyperparasitic nature.

The distinctive feature of Helopeltis spp. is a drumstick (see Fig. 3) organ attached to the middle of the thorax. The function of this organ is not clearly understood but it has been suggested that it is a portion of the sensory apparatus. An insect very closely allied to Helopeltis, and resembling it in every manner except that it does not possess the drumstick appendage, has been found in the Nilgiri Wynaad ; fortunately, it seems to confine its attention almost exclusively to jungle trees. It is a species of Disphinctus, probably Disphinctus Politus (see *Some South Indian Insects*, page 489).

Method of attack.—The insect, either in the form of the larva or adult, extracts the sap from the young leaves, by inserting its proboscis into the tissue and penetrating to the vascular bundles, through which the plant sap is flowing. The appearance of the punctures made are dependent upon the age of the insect. The adult makes large punctures and these are not confined to the young bud leaves, nor are there many punctures per leaf. A young larva, just hatched, invariably confines itself to the young bud leaves, and the punctures are numerous small discolorations, which often join up. From observations made in Central Travancore, the larvæ would appear to do more damage to the young bud leaves, and a close inspection would seem to indicate that most of the loss in crop is caused by the young larvæ, rather than by the adult insect. It would seem that the adult contents itself more in the puncturing of slightly older leaves and the midribs of leaves, and is probably more concerned with the matter of propagation of its species than in feeding. Old bites turn very dark brown to black, and

an attack which has taken place some time ago leaves the foliage with a wrinkled appearance, and holes, representing the remnants of the punctures are to be found. It might be said that the damage to the young tip is almost exclusively caused by the young larvæ. These tips invariably die and it is the capacity of the bush to send forth fresh buds which determine whether the attack of Helopeltis will be felt to any serious extent. If the bush is capable of sending out new buds, and of enabling these to develop strongly and at a greater rate than the insect can attack them, then the bush is capable of holding its own against the pest. If, however, the bush is incapable of flushing to this extent, the insect gains the upper hand and as the young buds are produced the insect is given plenty of time to attack them, with the result that the bush fails to flush further. Acres of sluggishly flushing bushes then present the deplorable state termed 'Black with Helopeltis'. It was observed that dark leaved jats were much more liable to this condition than light leaved jats, for in the fields noted in Central Travancore, the dark leaved jat of bushes had practically ceased to flush, whereas the lighter leaved jats were still sending out new shoots.

The indirect method of controlling the pest is based on this fact, that provided the bushes are capable of flushing in spite of an attack, the damage caused by Helopeltis would not be felt so much. Hence, all attention in Helopeltis areas should be paid to improving the health of the bushes by careful treatment such as careful pruning, careful plucking combined with easy treatment, and appropriate manuring.

The insect usually feeds prior to and after the hours of hot sunshine. During the hot portions of the day the insects take shelter from the sun in the

shadier parts of the bush, and are to be found on the under surface of the leaves. This affects direct control in that the most favourable times for the application of insecticides are early morning and evening.

To recapitulate.—From the foregoing observations made on the life history of Helopeltis spp. the main points bound up in the control of the pest are as follows :—

(*a*) Embedment of the egg in the tissue.

(*b*) Position of the egg on the bush.

(*c*) The overlapping of generations.

(*d*) Effect of climatic conditions on development.

(*e*) Resistance of bushes to attacks and capacity of bushes to flush under an attack.

(*f*) Peculiarities of the adult insect itself, e.g., time of feeding, sluggish flight, dislike of direct sun, susceptibility to attack of parasitic agencies, etc.

Methods of control.—Based on the foregoing six points relative to the presence of the insect various methods have been devised for controlling the pest. Hence we have the following :—

(*a*) Plucking off of shoots containing eggs, based on position of eggs.

(*b*) Assisting the bush to withstand the attacks of the pest.

(*c*) Hand catching.

(*d*) Employment of parasitic agencies.

(*e*) Spraying.

1. *Plucking off of shoots containing eggs.*—There cannot be any doubt but that a tremendous number of potential insects are destroyed as the result of the plucking. As has been stated, the eggs are deposited in almost any position of the bush where the tissue does not offer any marked resistance to the entry of the insect's proboscis. The natural position is in the young leaves on the top of the bushes, but it would seem that the insect regulates oviposition depending on the climatic conditions and the condition of the bushes. Thus, in North India during climatic conditions which are unfavourable to its development, viz., during the cold weather it deposits the eggs on the lower portions of the bushes, and hence the eggs are not plucked with the crop and further escape from the annual pruning. In distinction to this, in South India, there is no period at which the climatic conditions offer excessive cold, and one can safely assume that the insect is always capable of developing at a comparatively rapid rate. A fact which also supports this is that practically throughout the year, the insect is always present in South India on the tea bushes without any apparent period of hibernation.

One fact which may tend to make the insect deposit its eggs lower down in the bush than on the flushing area is the intense heat which the young larvæ would have to stand on hatching from the eggs during certain months of the year. It has been determined by Leefman that larvæ exposed on a dry sunny ground almost immediately succumbed and this indicates their susceptibility to excessive heat. Normal preservation of species would force the female insect to deposit its eggs in some position which would eliminate the possibility of the young larva on hatching from the egg being exposed to the sun.

The system of plucking in South India must bear an important relationship in attempting to deal with the eggs by plucking. To consider North India first of all—with the possible exception of the Dooars, the general practice of plucking is down to the Jhannun, or fish leaf. Thus all the leaves of the flush are removed, and any eggs contained in them destroyed. In South India without exception, the rule is to leave one leaf above the fish leaf; this lower leaf is certain to contain eggs and these are left. The leaving of a leaf is essential for the health of the bushes in South India, for owing to plucking proceeding throughout the year combined with the fact that no rest is given to the bushes from one pruning time to another (2 to 3 years), the health of the bushes would be considerably impaired if the method adopted in North India of plucking to the Jhannum were instituted. A diminution in the health of the bushes would be fatal on fields attacked by Helopeltis and hence, one's purpose would be defeated.

Another point of importance in attempting to deal with the pest by removing the eggs from the bush is the period lapsing between the plucking rounds. In South India an average plucking round is eight or nine days. During the period when the time for hatching is low, this would seem to cope with the eggs deposited by the insect in the flushing area of the bush but as already observed, the insect makes provision for this by depositing its eggs lower down in the bush, than over the flushing area. During periods of favourable climatic conditions, the egg may be deposited after one round of plucking and the larvæ appear before the next, and this combined with the fact that one leaf possibly containing eggs is always left above the Jannun, would seem to indicate that an attempt to control

the pest by plucking would not produce good results.

2. *Assisting the bush to withstand the attacks of the pest.*—This is the basis of work for the purposes of controlling the pest, being carried out in North India. It must be said that it is an indirect method, but as all direct methods seem to have failed, it is impossible to neglect to impress this indirect view on Planters. Included in the factors which tend to improve the health of tea bushes are cultivation, pruning, elimination of diseased wood, shade, careful plucking, formation of good wood, and appropriate manuring.

Cultivation does not bear quite the same significance as North India where the possibilities of waterlogging are so great. As a general rule in South India with its tea planted on slopes, where the soil is of a sandy nature thus permitting percolation, and where heavy downpours of rain are experienced, cultivation can, and must be reduced to the barest limits.

Conditions of soil and climate are also such variable quantities in the various districts in South India that it is impossible to lay down a general rule with regard to the method of cultivation to be employed. It must suffice here, with the lack of further data to proceed upon, to state that everything bearing a relation to good cultivation which has been found in the particular district to improve the health of the bushes, must be done.

The factors of pruning, shade, and the elimination of disease with reference to their effect on the health of the bushes are inter-related and are of especial importance under conditions existing in Tea Districts in South India affected by Helopeltis. One of the

most serious diseases which affects the health of tea bushes in South India is Branch Canker of the old frame wood (more appropriately termed 'Wood Rot' by Gadd). Observations on this disease with regard to prevention have been made in my Annual Report for 1926–1927, and as they have a direct bearing on the matter of the health of the bushes I offer no apology for including them here :—

Four observations were made on Branch Canker of old wood which are worthy of note :—

(*a*) The more horizontal branches were suffering from canker to a greater extent than those with a vertical tendency.

(*b*) Only the upper surface of these horizontal branches are affected, unless the under and side surfaces had been exposed to fire, e.g., burning prunings near them.

(*c*) Branch canker was found to be much less prevalent under shade than in the open, and it is unfortunate that absolute figures as proof of this statement are lacking.

(*d*) Time of pruning.

These observations seem to indicate that by modifying the conditions under which the bush is situated and giving them more protection from the sun, branch canker would be considerably reduced. The modification might be made on lines such as follows :—

(*a*) Elimination of purely horizontal branches, or their protection from the Sun by some means.

(*b*) Systematic planting of shade.

(*c*) Pruning at such a time as to enable the bush to produce a certain amount of foliage and thus give cover to the bush before the hot weather sets in.

Difficulties in applying these modifications in practice are immediately encountered, for, it is by means of the horizontal branches that a spread is obtained ; shade is not advantageous from the point of view of the manufactured tea and insect pests ; and lastly, and most difficult, the alteration of time of pruning is fraught with labour inconveniences in some districts. Overcoming the matter of spread might be accomplished by reducing the spacing of bushes and by a system of pruning calculated to obtain a spread by means of a series of less horizontal branches ; systematic shading may affect the quality of tea to a certain extent, but a partial elimination of Branch Canker would easily compensate for this loss in quality. The time of pruning might be allocated to those months, depending upon the acreage being pruned and the labour conditions, which would leave an interval of about six weeks or more before the hot weather is expected, to enable the bushes to form foliage. Such a time would probably mean pruning a portion of tea during the period of heavy flushing about September and October, but on the other hand the bushes would be in plucking at the season when prices are highest, and further Branch Canker would be reduced. Considering that according to Rutherford, Branch Canker is responsible for a reduction of crop amounting to 20 per cent or more, the sacrifice of the flush during the heavy flushing months would be made up by the reduction of Branch Canker and the increase in flush obtained during the period of higher prices.

From the standpoint of Helopeltis, the question of shade is of significance. In North India there is very little information of a definite character from which one can decide as to whether the presence of shade trees or their absence has any control on the presence of the pest. In South India the estates

attacked by Helopeltis seem to be as seriously affected in the open as under shade. The point however which must be emphasized is the effect of shade on the health and flushing capacity of the bushes. By those who have visited estates in all parts of South India, the beneficial effect of shade on the health of the bushes will be readily admitted. The heat of the sun produces high temperatures, and is accompanied by practically no rain, and this persistent heat lasting over a few months must have a serious effect on the wood of the bushes left exposed to it. The fact that shade has been shown to have a definitely ameliorating effect on the bushes during drought periods, must emphasize the necessity in South India for the planting of shade on estates attacked by Helopeltis. It must be remembered that in South India one period of maximum attack by the pest takes place just after the period of drought, and bushes exposed to the full heating and drying effect of the sun would naturally be in a debilitated state of health, and hence more susceptible to the attacks of Helopeltis, than bushes which have been kept freshened under shade. The small deterioration in the quality of leaf is a matter negligible compared with the damage done by Helopeltis, and it will be readily admitted that it would be worth while sacrificing a certain amount of quality provided the crop remained at a reasonable amount.

One point further with regard to shade in South India is its indirect influence on the control of Helopeltis by reducing Branch Canker to the minimum—a matter which has been touched upon a few paragraphs previously. I do not think the value of appropriate shade on South Indian Tea Estates can be sufficiently emphasized.

It is necessary now to discuss the affect of plucking on the health of the bushes. It is an extremely common thing in South Indian Districts to find Planters maintaining the conception that 'to pluck the flush before Helopeltis removes it' is the correct standard. Briefly and to the point, it must be stated that this is a shortsighted policy which cannot be too highly deplored. No consideration is given to the effect of too harsh plucking on the health of the bush.

To commence from pruning time,—it is a well-known fact that the bushes furthest removed from pruning, seem to be able to cope with the pest, better than bushes in the tipping stage. This may be merely the result of a superficial observation, for on bushes well away from pruning there is relatively a large amount of foliage unattacked, and hence the damage due to Helopeltis does not seem so severe. Only too often it is found that owing to attacks of Helopeltis becoming severe on pruned bushes, the Planter proceeds to tip the bushes before they are ready for it. The result is that the bushes after two years' growth have formed no wood suitable for pruning and the bushes are a mass of thin spindly branches, without any really good branches on to which to prune. This cannot but be detrimental to the health of the bushes especially when one remembers that it is on this weak wood, that the foundation for the following three years' flush must be laid.

Suggestions for ameliorative procedures against Helopeltis must be made with a certain amount of trepidation when not based on some sound experimental evidence and proof; I make the following suggestions with regard to tipping and the health of the bushes, realizing at the same time that they may be cast aside by some as the ramblings of a theorist.

Pruning, until comparatively recent times, had generally been carried out in the hot weather, e.g., December, January, February. The time for tipping therefore on normal bushes would be approximately the middle of February, March and April respectively depending upon the altitude of the estate. Now March and April coincide with the commencement of bad attacks of Helopeltis, and the result is that Planters tip too soon in order to obtain the leaf and not leave it at the mercy of Helopeltis. Could this not be avoided by regulating pruning so as to have the bushes ready for tipping at a time coincident with a period of minimum attacks from Helopeltis? After November, the attacks of Helopeltis commence to decrease owing to the commencement of cold winds during the evening, and extreme heat during the day; pruning in September, October, would bring the bushes to the tipping stages in November, December, or, allowing a longer period, December, January. The attacks of Helopeltis commence in real earnest in March, April, and hence the bushes would also have February and March during which to strengthen up the wood and be in a healthy condition to resist the ravages of Helopeltis. Combined with this advantage, would be the contribution towards the elimination of Branch Canker by early pruning as explained in the portion cited from my Annual Report (q.v).

To return to the conditions existing at present,—it might be argued by the Planter that if the bush were not tipped before Helopeltis attacked it, that the bushes would not flush at all afterwards. However it must be borne in mind that permitting the bushes to rest would do a world of good in maintaining their health and permitting it according to their own natural standards to resist the disease. To

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subject bushes to mutilation just prior to an attack of disease is hardly justifiable,—they should be left to their own devices. This may mean a loss of crop, but the rest which the bushes would have as the result of this consideration, would tend to enable the bushes to flush to a far greater extent during those periods when Helopeltis is not to be found in such large quantities; and most important it would be possible for the bushes to form wood for pruning purposes.

A similar state of affairs is to be found in the treatment of bushes at the period of their maximum yielding capacity. As soon as a bad attack of Helopeltis is imminent, the bushes are invariably plucked as hard, if not harder, than previously. The result is that the bushes feel the attack of Helopeltis to a considerably greater extent and soon reach that state of exhaustion when they refuse to flush further. The result is that the tea has to be abandoned. The procedure of leaving the bushes unplucked for a month during the heaviest periods of attack is much sounder, and from results seen on Manjamullai Estate during the visit there, there can be no doubt as to the extreme advisability and wisdom of this procedure.

I do not propose stating anything in detail with regard to the effect of manuring on maintaining the health of tea bushes as I have already given the matter due consideration in my Booklet on 'The Principles and Practical Considerations involved in Tea Manuring.' Emphasis must however be laid on the necessity for mixtures for the promotion of the health of the bushes, not to gain as much crop off them in the most rapid possible time. Over-forcing manuring mixtures, i.e., those containing a large excess of nitrogen on fields which are in an unhealthy condition, e.g., diseased, possessing spindly wood, flushing capabilities poor, etc., represent an economically unsound method of procedure with tea. The first necessity for producing crops from tea is that the bushes shall be in a prime condition of health. My suggestions with regard to the appropriate manuring for this purpose have already been given in my Booklet (loc. cit.).

Mention must however at this juncture be made of Andrews' potash experiments. Subsequent to the publication of the Potash investigations carried out by Andrews, attempts have been made to apply this method as a control for Helopeltis but the results have not proved as satisfactory as might have been expected, and which were anticipated. It would seem that the vital factor operating is the method adopted in applying the potash to the bush. Its application to the soil, in excess, in the forms, of the two best known potash fertilizers—the sulphate and muriate (chloride) of potash would seem to be attended by no positive results. This has been experienced in North India and also in Central Travancore. The method of application claimed to have beneficial results is the immersion of the feeding rootlets in a solution of a potash fertilizer. This promptly demands a procedure, the cost of which would proceed beyond the limits of expenditure permitted to estates, and hence the impracticability of applying the discovery due to Andrews becomes patent. The adding of excess potash in manures might also be attended by detrimental results, especially on stiff soils, where apart from the presence of Helopeltis, such an addition would result in the deterioration of the tea, and would thus represent a serious obstacle to the utilization of potash as a control for Helopeltis.

From the foregoing paragraphs, it will be clear that keeping the bushes healthy is a matter more

easily said than carried out. Many interfering factors such as expenditure, labour conditions, etc. act as deterrents to the application of the utmost possible energy to the maintenance of the bushes in proper health. At the same time the necessity for doing all one possibly can in this direction must be emphasized to the utmost degree.

III. *Hand catching of Helopeltis insects.*—This is an ameliorative, rather than a preventive measure, and in South India is a course still pursued on many estates. All Planters, who have practised hand catching will admit its futility as a preventive measure, but at the same time they have observed that catching just prior to a heavy attack has helped matters. During a heavy attack hand catching is usually abandoned. The disadvantage of the method is the impossibility of expecting a really efficient search being made by the podians (small children). Even the most expert of these podians searching in their habitual manner cannot be expected to obtain at a maximum more than 40 per cent of the insects present on the area being searched. Further, catching is only carried out on a very limited area of the estate, the greater portion being unsearched. Clearly therefore the numbers caught might make a difference during the periods when the development of Helopeltis is at a minimum, but it becomes useless during periods of heavy attacks.

IV. *Employment of parasitic agencies.*—The possibility of introducing some organism utilizing the Helopeltis insect as a host has only been considered of recent years as a means of controlling the problem. The application of a fungoid parasite, termed Metarrhizium was attempted, but the success apparently attained did not hold out any probability of effectively controlling Helopeltis by its use. The

utilization of insect parasites has been attempted extensively, amongst which might be mentioned the mantis, beetles, spiders and ants and a mermithid worm. I do not intend enlarging on these as their use was attended by no practical success. I shall limit myself to the later work carried out by Dr. Menzel in Java on a parasitic wasp, termed Euphorus Helopeltidis. (See Fig. 5.) The information concerning this wasp has been gleaned from the original Dutch Journals, publications of the *Theeproefstation Voor Thee* at Buitenzorg, Java.

In considering the introduction of an insect parasite, a number of important aspects must receive attention.

(*a*) The parasite should be capable of outnumbering its host.

(*b*) The parasite should be specific in its action.

(*c*) The parasite should be able to adapt itself to fresh climatic conditions and possess greater powers of dispersal than its host.

(*d*) It should be comparatively free from enemies and competition of other parasites on the same hosts.

Immediately it may be said that the fulfilment of these conditions represents real difficulty. It was found that in order that Euphorus should outnumber Helopeltis it was essential to breed the wasp actually on the estate. A large number of estates in Java are at present carrying out experiments on these lines, and good results are being obtained.

Euphorus is not specific in its action on Helopeltis. It has been suggested that it was parasitic on worms and grubs and only turned its

attention to Helopeltis when there was a dearth of these other hosts. It was found during an attempt on the part of Dr. Menzel to find Euphorus in Sumatra that the larvae of Pachypeltis, another member of the Capsidae family, were infected by Euphorus larvæ. The fact that these parasitic larvæ were found to resemble those of Euphorus Helopeltidis suggested that the Pachypeltis had been infected by this species, or at least, by a species of Euphorus very closely related to E. Helopeltidis. This further indicates that Euphorus is not specific on Helopeltis, but it would seem to confine itself in the main to the Capsidæ family.

Euphorus spp. are small wasps which appear to be indigenous to Java, and are parasitic on Helopeltis and the allied Pachypeltis. Hence this eliminates the necessity for the adaptation of the wasp to the climatic conditions existing in Java. One fact is apparent from investigations carried out, viz., that the wasp is not capable of existing at altitudes higher than about 4,000 feet above sea level, but as this also applies to Helopeltis, it does not represent any obstacle to its application as a control for Helopeltis. Whether the wasp is capable of adapting itself to South Indian conditions is a matter for experiment, and negotiations are at present being made with the Java Experimental Station for a number of wasps for the purpose of experiment. It is highly probable that we already have a wasp, indigenous to South India which is parasitic on Helopeltis and investigations along this line might prove of value.

Some details as to the habits of Euphorus are available and are reproduced here. Altogether three species of Euphorus are known, viz., E. Helopeltidis, E. Xanthostigma and E. Nigricarpus. The last

two originated from Africa and were described in 1913 by Szepligeti, but their hosts were, and still are, unknown. E. Helopeltidis resembles E. Nigricarpus but may be differentiated by definite characteristics. E. Helopeltidis possesses antennæ with 27 divisions, not thickened at the ends. Head and thorax are black, hind legs yellow, and the exterior end of the tibia brown. The length of the wasp in Java is 1/8" (3 mms). Ferriére enlarges this description as follows: Head transversal, very broad behind the eyes. Antennæ threadlike, brown, but yellow at the base. Mesonotum smooth, lightly spotted. Metathorax wrinkled, scutellum smooth with two pits round the base. The stigma brown; the wing veins, yellow. Legs long, hips rounded. The first segment of the abdomen possesses broad grooves, and the aspiratory apertures. The second segment is very large, smooth and shiny. The other segments are completely covered, length 1/8", span of wings 3/16". From this description and by a glance at the figure (Fig. 5), sketches from a similar figure in *De Thee*, it should be possible to recognize the wasp.

The wasp confines its parasitic activities to the young Helopeltis larvæ. At an early stage in the development of the host, the wasp deposits its eggs in the abdomen of the victim. From this egg emerges the wasp larvæ which are then capable of feeding on the non-vital portions of the Helopeltis larva. This they continue to do until they are in a position to leave the host, which they apparently do before the Helopeltis larva has reached the adult stage.

An infected Helopeltis larva is usually very swollen, and the colouring is not normal. Almost the whole of the abdomen is white or yellowish, and the red colour is confined to the hindmost

portion of the body. If such a Helopeltis larva is carefully opened up, the white maggoty larvæ of the wasp emerge from the aperture made. The evidences of the wasp in very small Helopeltis larvæ, or of the wasp embryo are very difficult to find. Also, the discovery of the cocoon which the wasp spins in the soil is almost never, or only by accident to be found.

It must be admitted that in the discovery of the parasitic properties of Euphorus on Helopeltis, one of the greatest advance in the direct control of Helopeltis has been made. Investigations on an extensive scale are being carried out in Java, which will throw further light on the possibility of the application of the wasp successfully to the pest. In this connection, the presence of a hyperparasite, i.e., an agent parasitic on the wasp, might seriously hamper the progress in the breeding of the wasp to the extent desirable. Such a hyperparasite has been found. During attempts to breed Euphorus Helopeltidis in the insectory, another type of wasp was found in the cocoon, which would seem to belong to the Stichlopisthum family, and is apparently parasitic on Euphorus.

Spraying.—Innumerable attempts to control Helopeltis by various contact insecticides have been made but with a degree of success hardly commensurate with the expenditure. The difficulty of spraying tea bushes with a liquid contact insecticide is very great, the main disadvantage being that the complete foliage does not receive treatment except at a tremendous expenditure in time and labour. An insecticide whose killing properties did not depend upon contact would largely overcome the difficulty. One which would further dispense with the necessity for carrying water would be a great advantage, and such an insecticide, if in a finely divided state of division, would be capable of penetrating a tea bush much more readily than a liquid insecticide. Such a non-contact insecticide is calcium cyanide dust. In the following paragraphs an attempt has been made to detail the experiments carried out in September and October 1927 with the object of determining the possibility of applying calcium cyanide as a means of controlling Helopeltis.

FURTHER INVESTIGATIONS ON THE APPLICATION OF CALCIUM CYANIDE AS A CONTROL FOR HELOPELTIS

The damage done by Helopeltis in most tea districts makes it impossible for us to neglect any opportunity of attempting to deal with the pest. The introduction of calcium cyanide as an insecticide offered such an opportunity, and it was immediately seized upon. The preliminary experiments of 1926 were the result and it was seen that under certain conditions, the effectiveness of calcium cyanide, correctly applied, as an insecticide was far above that of other insecticides used previously, and possessed certain real advantages which will be enlarged upon later.

Following the preliminary determinations made with calcium cyanide against Helopeltis in June 1926, and reported in the *Planters' Chronicle* of 7th August, 1926 (q. v.), it was decided that experiments on a larger scale and over a larger area should be carried out. For this purpose one ton of calcium cyanide was placed at the disposal of the Travancore Tea Estates by the American Cyanamide Co., New York, on the condition that a Scientific Officer should be present to conduct the experiments. It was arranged therefore that the Tea Scientific Officer of the United Planters'

Association of Southern India should proceed to Munjamullay Estate in September 1927 in order to carry out the projected experiments.

The rather encouraging results obtained in the preliminary experiments carried out in 1926, led us to expect some real advance in dealing with Helopeltis by the application of calcium cyanide on a large scale. This expectation was further enhanced by the excellent results obtained by the application of calcium cyanide to other insect pests of cultivated crops amongst which might be mentioned thrips, citrus pests, etc. At the outset, however, in spite of the encouragement received, doubts were held as to the possibility of effecting a permanent means of controlling Helopeltis. This can hardly be wondered at when one remembers that in spite of over fifty years of attempts at controlling the disease, very little advance has been made. In fact, even before these attempts to apply calcium cyanide as a control were contemplated, it was felt that direct methods of attacking the problem would be of very little avail against an insect possessing such characteristics as the Helopeltis insect.

Description of calcium cyanide dust.—The grade of calcium cyanide used in the experiments was that termed the 'A' dust. It contains not less than 40 per cent and not more than 50 per cent of calcium cyanide, and is a fine greyish-blue dust, about 80 per cent passing through a 200 mesh and smelling strongly of calcium carbide. The insecticidal properties of the dust are due to the evolution of hydrocyanic acid (prussic acid) gas, when the dust comes in contact with moisture. The main factor affecting its efficacy when applied is the amount of water vapour present in the atmosphere at the time of dusting. It has been found that if the relative humidity of the atmosphere is 50 per

cent or more, 90 per cent of the available poisonous element is evolved in the first two and a half hours after exposure.

Application of calcium cyanide.—The application of the dust is made by means of a dusting machine, especially adapted to use with calcium cyanide. (See Fig. 6.)

Preliminary experiments.—It was first of all necessary to determine the following points in the application of cyanide.

(*a*) Its efficiency as an insecticide.
(*b*) The minimum dosage required.
(*c*) Number of applications required.
(*d*) Its application with and without a trailer.
(*e*) Burning effect of the hydrated lime on tea leaves.
(*f*) Effect on labour.
(*g*) Advisability of dusting plants yielding a potable product with poisonous material.

Efficiency of calcium cyanide as an insecticide.—This point had been investigated thoroughly in the 1926 experiments. During these experiments the following results were obtained :—

No.	Treat-ment	No. of lbs. per acre.	No. of bushes involved.	Temperature		Relative humidity.	No. of insects alive after treatment.	
				Wet bulb.	Dry bulb.		Larvae	Adults.
1	'A' Dust	111	53	73	73	100	1	0
2	'S' Dust	110	44	75	75	100	0	4
3	Control.	Nil.	48	...	...	...	119 insects alive including adults and larvæ.	
4	Control.	Nil.	43	68	68	100	28	20
5	'A' Dust	100	120	68	68	100	0	0
6	Control.	Nil.	30	...	...	...	13	30

It would appear that the 'S' dust is rather less effective in killing the insect. Owing to this, the 'A' dust was utilized in the experiments carried out this year, and no attempts were made to determine a suitable 'Filler' for the 'A' dust, for 100 per cent kill under the best conditions was considered essential, and further the introduction of a filler, e.g., in the form of powdered sulphur would increase the cost of the application owing to the charges and transport rates of the sulphur.

In order to confirm these results, twenty-five bushes were taken and the number of insects found by podians determined. On the twenty-five bushes ten adults and thirty-three larvæ were obtained. Another twenty-five bushes were taken and each bush received four pumps of cyanide from the duster. After this treatment no live insects were obtained by the podians after repeated search, and the possibility of obtaining 100 per cent by the application of cyanide under proper supervision was ensured.

The power of the insect to recover when receiving a direct hit from the spray is nil. If an insect flies from the bush when the bush is being sprayed and merely flies through the dust cloud, it is usually incapacitated and drops to the ground. One such insect was taken into fresh air, and it was found that recovery, though slow, did actually take place. An insect receiving a direct hit, or remaining on the bush while it is enveloped in the dust dies within a small fraction of a minute after contact with the cloud of cyanide or the dust.

Under practical conditions of spraying, it is however impossible to expect a 100 per cent efficiency from the application of calcium cyanide.

Without European supervision throughout the dusting (a practical impossibility on a Tea Estate) bushes are inadvertently omitted from the spraying, and others are only incompletely dusted. Further it was found essential to spray round the bole of the bushes in order to destroy insects falling from the bushes when they are disturbed. The omission of this precaution has an important influence on the efficiency of the dusting.

In order to determine an approximate idea of the efficiency under practical conditions, the number of live insects on 1,168 bushes which had received one application of the cyanide was determined by sending podians over these bushes three days after it had received a spraying. The count was as follows :—

No. of bushes	Adults	Larvæ of a size indicating hatching since time of spraying	Large larvæ
1,168	164	240	57

On a check number of unsprayed bushes the count was as follows :—

No. of bushes	Adults	Large larvæ
55	29	21

In order to correlate these two counts, the number of insects on the fifty-five bushes was brought up proportionately to the number which might be expected on 1,168 bushes, though this would not necessarily represent the actual numbers to be found. According to this calculation the numbers of live insects which would be found on 1,168 bushes would be : Adults : 615. Large larvæ : 446. Hence number of insects killed by spraying would be the sum of

these numbers amounting to 1,061 less the number of live insects found, equal to 221, which is 840 insects. The percentage kill, therefore, under practical conditions might be expected to be $\frac{840}{1061} \times 100 = 79{\cdot}2$ per cent.

Minute larvæ which must have developed since the time of spraying were neglected in both cases as not having come under the treatment. One important point however must not be neglected in this direction, viz., the possibility of adult insects flying from the unsprayed area to the sprayed area. Many bushes unsprayed, and in close proximity to the 1,168 bushes, separated indeed only by a road, were found to have as many as four or five adults on them. Assuming this reinfection from external unsprayed portions one might safely raise the percentage kill under practical conditions with calcium cyanide to a minimum of 85 per cent.

The importance of the European supervision both as regards efficiency and from the standpoint of the economics of the situation cannot be overestimated. The uncomfortable nature of the dusting owing to the necessity for coolies to remain in the clouds of dust tend to make the coolie careless of how the dusting is done, provided he can escape the discomforts of remaining in the cloud for any long period. Hence European supervision is necessary for the maximum possible efficiency. Continual European supervision is impractical, for on an Estate of say 600 acres with two Europeans to maintain the ordinary routine works of plucking, pruning, factory work, etc., it is impossible for one of these Europeans to remain supervising the dusting. The cost of such dusting with European supervision would also be too great and with the economic position of dusting with cyanide already precarious owing to the high price of cyanide, the extra

condition of European supervision would entirely undermine the value of dusting.

One other factor entering into the question of the efficiency of calcium cyanide under practical conditions is the efficiency of the dusting machine. I do not propose in this report to enter into the details of the dusting machine, which is a product of the American Cyanide Co. and which is shown diagrammatically in Fig. 6. One observation made however was that the efficiency of the duster depends upon the quantity of dust contained in it. When full a good cloud of dust is obtained, the volume of the expelled dust decreasing as the dust in the container decreases. It is essential that the container be kept well filled with the calcium cyanide dust. Naturally, this factor, which might be considered almost negligible, affects the economics of the situation, for considerable time is lost owing to the need for replenishing the containers before the previous supply has been exhausted.

The factors affecting the efficiency of an application of calcium cyanide to Helopeltis are, therefore:

(*a*) Necessity for European supervision.

(*b*) Thorough dusting, obtained by three pumps of dust into the foliage of the bush and one round the bole of the bush.

(*c*) Power of recovery of insect from the dust.

(*d*) The efficiency of the duster depending upon the amount of calcium cyanide dust present in the container.

(*e*) Climatic conditions.

Minimum dosage.—This is of importance from an economical point of view. From the table already given of the 1926 experiments it will be noted that the doses of calcium cyanide applied were in the neighbourhood of 100 pounds per application per acre. Owing to the price of calcium

cyanide this amount of cyanide per acre would entirely eliminate it from the realms of possibility as an economical control for Helopeltis. The small scale on which the 1926 experiments were carried out made the determination of dosage open to many errors, capable of producing very appreciable divergencies when calculated as a quantity per acre. On the 23rd September, therefore, 477 bushes were taken and each received a thorough dusting with calcium cyanide, the amount utilized for this purpose being five pounds. On the assumption that there are present 2,400 bushes per acre, this would represent an application of twenty-five pounds of dust per acre. This decrease in dosage is extremely great, and at first sight it was felt that the efficiency of the spraying might have been impaired by such a decrease. However the spraying was carried out under personal supervision, the number of pumps of dust given per bush was the same as that giving 100 per cent kill in the tests to determine the efficiency of calcium cyanide as insecticide and further the number of live insects obtained was nil. This determination was of extreme importance, for it reduces the cost of the calcium cyanide per single application per acre to 25 per cent of what the cost was as determined in the 1926 experiments.

Minimum Number of Applications and Interval of time between Applications.—In order to understand clearly how it was decided that two applications should serve to eliminate the insects from a given area, and the interval of time to elapse between the applications, it is necessary to refer to those paragraphs dealing with the life history and peculiarities of the insect as related to its control (see page 3 *et. seq*).

For the purpose of the present experiments the determination of the interval of time between

applications and the number of applications required to eliminate the insect completely, the time taken for the insect to reach maturity from the deposition of the egg was taken as fifteen days. Assume for purposes of explanation that at the first application all the adults and larvæ are eliminated. The remnants of the pest are the eggs which may be at various stages of development, some freshly deposited just before spraying, and others on the point of hatching out immediately after spraying. The object of the second application is to ensure that none of these larvæ or eggs, which are potential egg layers, shall reach the stage of maturity. Eggs, deposited five or six days prior to the first application will have hatched and become larvæ, or will be ready to hatch immediately after the application ; it is the control of these larvæ which must be undertaken. Assume an egg has been laid at such a time prior to the application of the insecticide that it hatches at a time just subsequent to the application, of the calcium cyanide, when its insecticidal properties will have been lost. The resulting larva will proceed through its moulting stages and become an adult after nine days at the period of its maximum rate of development (see Table IV). A second application made nine or ten days after the first application should prevent this larva from attaining maturity and hence preclude the possibility of its depositing eggs. Such an interval between applications would also deal with eggs laid by adults immediately before their destruction by the first application, for these eggs after seven or eight days would be in the form of larvæ and hence amenable to the destroying activity of the second application. On the assumption, therefore, that we have no reinfection from outside the area treated with calcium cyanide, and that a 100 per cent kill has taken place at the first application, every insect possible should have been destroyed by two applications with an

Burning effect of hydrated lime.—As is well known, the action of calcium cyanide when exposed to a definite degree of humidity is to evolve hydrocyanic acid gas (the poisonous element in the dust) and leave a residue of hydrated lime. The determination whether this hydrated lime, which remains after dusting tea bushes, had any caustic effect on the foliage was important. One particular bush was given a large application of the dust, representing the remains of the dust in the containers. After a week or so, the leaves had turned brown indicating that they had been effected by the hydrated lime. However, on the bushes receiving the normal amount of dust, no caustic effect whatsoever was noted, either on the young flush or on the older leaves.

Effect on labour.—It may be stated immediately that dusting was not favoured by the coolie labour. Owing to the necessity for standing in clouds of the dust, it was soon found that the nose and throat became troublesome, owing to the effect of the hydrated lime on the mucous membranes of these organs. Another incident not tending to increase the popularity of dusting among labour was the temporary incapacitation of one of the labourers, who, while spraying, insisted, in spite of repeated warnings, in commencing a new wad of betel nut, which unfortunately received a quantity of the calcium cyanide adhering to the coolie's hands. However, he was soon resuscitated but refused to continue spraying. There is no doubt that dusting with calcium cyanide may become extremely unpleasant and this fact can be corroborated both by the manager of the Estate and by the writer of this article.

Effect of poisonous gas on plants yielding a portable product.—This is a matter of great importance. However, owing to the peculiarity of calcium

cyanide in evolving its poisonous element practically completely within forty-eight hours, and owing also to the period of seven, eight, or nine days elapsing between plucking rounds, it may be safely accepted, that, provided the dusting is done just subsequent to a plucking round, no poison will be found in the made tea. It is intended carrying out chemical analyses of tea sprayed with calcium cyanide, in order to determine the amount of residual poison, if any, but it is felt that these analyses will not produce any results which would be likely to interfere with the application of calcium cyanide to tea.

The foregoing completes the descriptions of the preliminary experiments and observations, and I shall now proceed to describe the actual field experiments carried out—

Site of experiments.—A field comprising fifteen acres was taken as the piece of tea affected by Helopeltis on Munjamullai most promising for the purpose of the experiments. The degree of attack was not great but the insects were present to a large extent and the depredations of the pest seemed to be increasing. The field was eight months from pruning at the time of carrying out the experiments and was hence in a condition favourable for an attack of the pest.

The experimental plots.—Owing to the large acreage to be sprayed it was impossible to attempt taking observations on the total acreage. Smaller plots were therefore taken in the sprayed area and submitted to differential treatment. It will of course be readily understood that the possibility of obtaining a uniform piece of land was very remote. The lie of the land, the spacing of the bushes, presence of vacancies, difference in size of bushes, and other conditions prevalent, combined to eliminate to a certain degree the accuracy of the experiments.

Fifteen plots were selected, however, each to include as near as possible 200 bushes.

Each of these 200 bushes in each of the plots could not be examined individually for the degree of attack, but it was felt that taking a smaller number would increase the inaccuracy. Further as it was intended to note the yield of green leaf from each plot, too large an error in the weight of the crop would be introduced by considering a smaller number of bushes.

Figure I reproduces the arrangement of the plots, the numbers inserted representing the number of bushes (exclusive of vacancies) present in each plot.

FIGURE I.

Plot 15 Experimental 209 bushes	*Plot 6* Experimental 240 bushes	*Plot 5* Experimental 190 bushes
Plot 14 Sprayed (Non-experimental) 216 bushes	*Plot 7* Sprayed (Non-experimental) 222 bushes	*Plot 4* Sprayed (Non-experimental) 199 bushes
Plot 13 Control No treatment 205 bushes	*Plot 8* Control No treatment 162 bushes	*Plot 3* Control No treatment 187 bushes
Plot 12 Sprayed (Non-experimental) 271 bushes	*Plot 9* Sprayed (Non-experimental) 271 bushes	*Plot 2* Sprayed (Non-experimental) 239 bushes
Plot 11 Experimental 182 bushes	*Plot 8* Experimental 158 bushes	*Plot 1* Experimental 231 bushes

The plots were separated from each other by a narrow trench.

The object of the 'sprayed, non-experimental

plots' was to ensure that the incidence of external infection on the control plots would be reduced to a minimum. Further, as the experimental area was included in the field completely sprayed, the possibility of infection from the surrounding bushes was also reduced to a minimum.

Treatment of plots.—It had been noted in the preliminary experiments that four pumps from a well filled duster was sufficient to envelop the bush completely in the cyanide dust. This was therefore maintained as the standard dosage over the experimental plots. Plots 1, 2, 4, 5, 6, 7, 9, 10, 11, 12, 14, 15 received this dosage of cyanide. Plots 3, 8 and 13 were kept as control plots. On the 30th September the plots were plucked and the amount of green leaf weighed. On the 3rd October the experimental plots received the first application of cyanide. Previous to this all the surrounding fifteen acres had received an application. On the 11th October, the bushes were again plucked and leaf weighed and the second application of cyanide made on the 13th October. The plots were again plucked on the 19th October. The results obtained from these determinations were as follows :—

Plot	No. of bushes	Before dusting		After 1st application		After 2nd application		Total leaf obtained after dusting
		Date when plucked	Weight of leaf in lbs.	Date plucked	Weight of green leaf in lbs.	Date plucked	Weight of green leaf in lbs.	
1	231	30-9-27	2·0	11-10-27	4·5	19-10-27	3·0	7·5
3 Control	187	,,	2·0	,,	4·0	,,	3·0	7·0
5	190	,,	2·0	,,	6·75	,,	4·0	10·75
6	240	,,	2·5	,,	4·00	,,	3·0	7·0
8 Control	162	,,	1·0	,,	2·25	,,	2·0	4·25
10	158	,,	2·5	,,	3·5	,,	1·5	5·0
11	182	,,	2·5	,,	4 5	,,	5·0	9·5
13 Control	205	,,	4 0	,,	6·0	,,	3·0	9·0
15	209	,,	3·0	,,	6·0	,,	5·0	11·0

PREFACE

Four reasons have been the incentive for the production of this pamphlet on Helopeltis,—a subject concerning which a considerable amount has been written since its discovery as a serious pest of Tea in the mid-years of the last century.

The reasons briefly are as follows :—

1. A desire to reproduce for those Planters in Helopeltis stricken areas, all the most important facts derived from previous investigations on Helopeltis, in some compact form.

2. The necessity for an appropriate medium for the representation of experiments carried out on Helopeltis with calcium cyanide.

3. A desire to bring before the notice of South Indian Planters, investigations being carried out in North-East India and Java on Helopeltis.

4. A desire to indicate to Planters in those districts at present free from Helopeltis, the necessity for keeping a watchful guard against the incidence of the pest, and enabling them to identify the insect and take whatever precautionary measures are at present available.

It is to be hoped that at least the attempt to warn Planters of the necessity of preventing such a pest as Helopeltis from gaining a strong position in districts at present comparatively free will not be fruitless.

Each plot was plucked by the same plucker in every case as nearly as possible. The first application was made with an atmospheric humidity of 89 per cent, and the second with an atmospheric humidity of 74 per cent. Combining the amounts of green leaf obtained from the control plots and those from the dusted plots the following was obtained :—

Nature of plots	Yield before dusting	Total yield from two plucking	Per cent Increase on yield before dusting	Per cent Increase of dusted plots over control plots
Controls ...	7·0 pounds	20·25	289·0 per cent	21 per cent
Dusted	14·5 ,,	50·75	350·0 ,,	

From this table, we find that the dusted plots have increased in yield after dusting by 21 per cent. as compared with the control plots.

Observations made after a fortnight over the whole fifteen acres sprayed indicated that definite benefit had been derived from the spraying. Dark leaved bushes which had failed to flush at all owing to the presence of the pest, had commenced to throw out shoots, and over the complete area flushing was proceeding vigorously. In the observation of the young flush it was clearly demonstrated that the activity of the larvæ (responsible for most damage to the young leaves) had considerably decreased, though even after two sprayings fresh larvæ and adult bites could be found. This was no doubt due to the fact that certain of the insects had escaped from the treatment owing to the difficulties encountered in obtaining the most ideal method of applying the dust to give 100 per cent kill (see paragraph on efficiency of calcium cyanide as insecticide). Admitting, therefore, that definitely beneficial results on the health and the yield of the crop have been obtained it is

necessary to consider the advisability of applying the material, from the most important standpoint of estate economics.

The economics of the situation.—In considering the economics of the situation we shall take the factors contributing as applied to the fifteen acres dusted. 21 per cent increase has been claimed over three weeks plucking in October as being due to the application of the cyanide. Naturally, one cannot take this as the increase over a year, for owing to climatic conditions, the pest spontaneously decreases its activities almost to a negligible quantity, and further it cannot be assumed that the application carried out in September, October will have any effect on the severity of the attack in May, June. It is necessary therefore to confine ourselves to a consideration of the increase in crop over the period when the influence of cyanide would still be felt. Assume spraying were commenced on September 1st then September, October and November crops only may be considered as being influenced as these crops are the most likely to be affected by the treatment. For purposes of convenience and illustration the percentage increase which shall be ascribed to the application shall be taken as 20 per cent above the yield of areas not receiving dusting treatment. It is necessary to decide what this increase will mean when converted into pounds of made tea. From figures of crop yield submitted by the Manager of the Estate, the average percentage of the total annual yield produced during the months of September, October and November is 27·75 per cent, this average being taken for the crop figures from January 1923 to December 1926, and including one pruning cycle. The acreage dusted shall be taken as capable of giving a yield of 700 pounds made tea per annum per acre.

Hence the amount of tea obtained during September, October and November is 27·75 per cent of 700 = 194·25 pounds. By dusting, this amount is increased by 20 per cent, realizing an increase of 20 per cent of 194·25 = 38·85 lbs. Assuming the profit on one pound of tea to be 8 annas, the increase in profit due to dusting is equivalent to 38·85 × 8 annas = Rs. 19-7-0.

It must be borne in mind however that the area sprayed was by no means badly attacked by Helopeltis, but attacks were becoming severer. However considering the conditions under which the dusting was done, even with the most optimistic expectations a saving in crops equivalent to Rs. 19-7-0 only can be expected.

The cost of material and application were determined as follows :—

For two applications of calcium cyanide over the fifteen acres, amount required is 825 pounds or an average of fifty-five pounds per acre.

Taking the cost of calcium cyanide as Re. 1 per pound, the cost of material per acre for two applications is Rs. 55. Assuming the cost of transport at Rs. 20 per ton to the estate, the cost of transport on 55 pounds would be Rs. 0-8-0.

The cost of supervision and application was determined as Rs. 105-0-0 over fifteen acres making the cost per acre = Rs. 7-0-0.

Total cost of applying calcium cyanide per acre of tea is equivalent to Rs. 62-8-0.

Thus we have : Cost of application of calcium cyanide per acre of tea = Rs. 62-8-0.

Maximum benefit derived = „ 19-7-0.

These figures speak for themselves and indicate that the application of calcium cyanide as a control for Helopeltis is unfortunately impossible from the standpoint of economics.

The case of a field abandoned as a result of Helopeltis must be brought into the discussion. It can usually be stated that as much loss is occasioned owing to the weak health of the bush as by the presence of Helopeltis ; in other words the cause of the complete abandonment of any area cannot be ascribed to Helopeltis alone. To take a hypothetical case : A field of tea capable of yielding 400 pounds of tea per annum is abandoned in early September as the result of Helopeltis. Assume further that calcium cyanide is applied and the fields once again come into bearing, the October and November flushes being produced in normal amount. Assume 17 per cent of the annual yield to be obtained during this period. It might be stated at once that this 17 per cent is an extremely optimistic figure, as we are dealing with a field previously abandoned.

17 per cent of a crop of 400 pounds per acre would thus be saved, equal to sixty-eight pounds. This, at eight annas profit per pound would be Rs. 34 saved. The cost of applying cyanide would be Rs. 68-7-0 per acre, which makes the application of calcium cyanide as a remedy for Helopeltis attacks on abandoned areas also an impracticable policy.

As a digression, however, from the point under discussion, it is necessary to emphasize the utility of calcium cyanide on an estate. It is capable of dealing with almost any insect pest, and in the opinion of the writer would be invaluable for application to pests of tea nurseries. Land crabs, aphis, and scale

insects all succumb to its poisonous activity, and as has been shown, no fear need be entertained with regard to its damaging the foliage or hindering the growth of the seedling. The introduction of a hand duster would be an asset.

Summary.—In order to place clearly before the reader all the points determined with regard to the application of calcium cyanide to Helopeltis in tea, I have enumerated the following facts :—

1. Efficiency of calcium cyanide as an insecticide under the most favourable conditions is 100 per cent.

2. Efficiency of calcium cyanide as an insecticide under the most favourable practical conditions may be 85 per cent.

3. Efficiency of dusting machine is dependent upon amount of calcium cyanide contained in it.

4. Three pumps of the calcium cyanide from a well filled machine into the foliage, and one pump round the bole of the bush represents the minimum amount of dust for effective application to one tea bush.

5. An insect partially gassed is capable of recovery, but such a state of affairs is only the remotest possibility under the condition of dusting as given in 4.

6. Minimum dosage per acre averages 27·5 pounds of calcium cyanide per single application.

7. Two applications with an interval of nine days represents the best method of control for reasons given.

8. Number of dusters available control number of acres capable of being sprayed, and labour affects this question indirectly.

9. Climatic conditions are important—high humidity, absence of rain, and no wind.

10. The use of a trailer in the application of calcium cyanide to tea is impracticable.

11. Under the usual conditions of dusting, no caustic effect on the foliage was noted owing to the residue of calcium hydrate.

12. Effect on Labour is discouraging owing to the discomforts of standing in clouds of the calcium cyanide dust, effect of the dust on the mucous membranes, and strenuous nature of pumping work.

13. One coolie is capable of only two and half hours' dusting work, during which time 600 bushes, equivalent to $\frac{1}{4}$ of acre, may be dusted.

14. Effect of poisonous material such as calcium cyanide on the flush plucked for the making of tea may be entirely eliminated, by dusting immediately after a round of plucking, and the possibility of residual poison from the calcium cyanide is precluded by its characteristic property in emitting completely its poisonous element within forty-eight hours.

15. Dusting Helopeltis—attacked areas with calcium cyanide is capable of increasing crop by 20 per cent.

16. It is considered that this increase would only apply to the three months after spraying, at a maximum.

17. The economics of the situation entirely eliminate the possibility of the application of calcium cyanide as a control for Helopeltis either on partially attacked areas, or on completely abandoned areas.

18. Value of calcium cyanide as a control for insect pest in tea nurseries is considered very great.

19. Necessity for small hand duster is maintained.

Conclusion.—I should like to take the opportunity, in concluding this report, to express my appreciation of the hospitality shown me by the Manager of Munjamullay Estate, Mr. Cantlay, and by Mrs. Cantlay ; also for the unstinted and generous assistance given by them throughout the experiments. My thanks are also due to Mr. Sylvester, the General Manager of the Travancore Tea Estates, for enabling me to carry out experiments of this nature on Helopeltis, thus contributing to the attempts to find a means of combating such a prodigious pest as this insect represents to the culture of tea.

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OBSERVATIONS

ON

HELOPELTIS (TEA MOSQUITO BLIGHT)

FOR

SOUTH INDIAN TEA PLANTERS

BY

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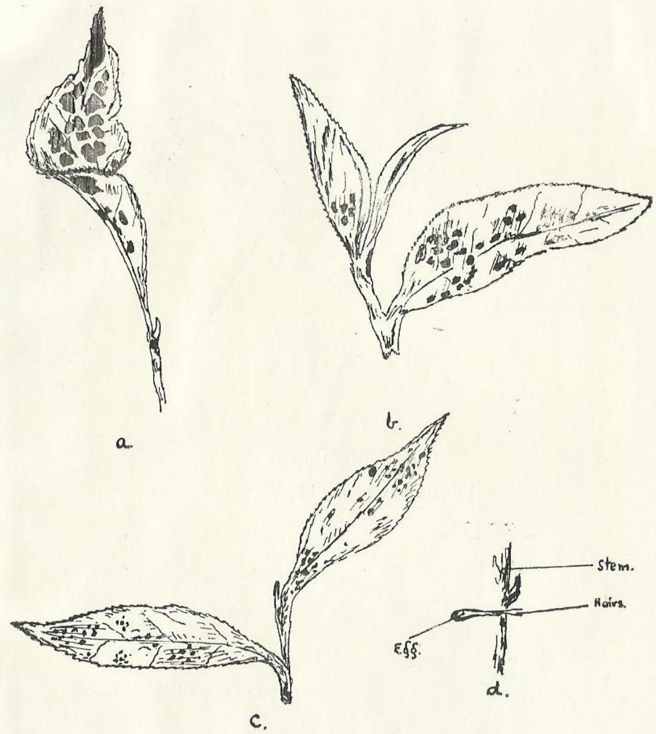

FIG. 1,

PUNCTURED TEA LEAVES.

a. Adult Punctures.
b. Large Larva Punctures.
c. Young Larva Punctures.
d. Egg in Tissue.

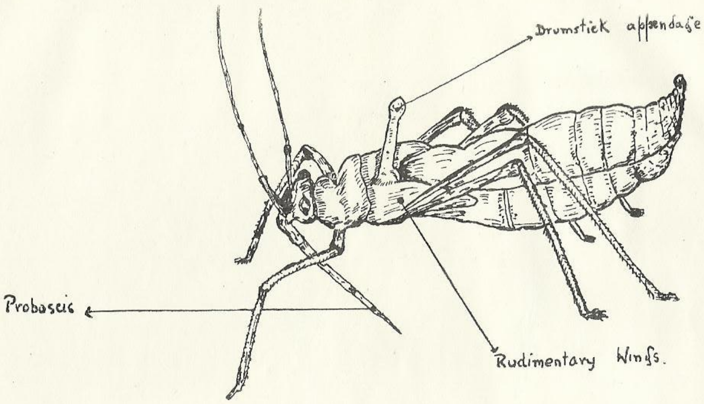

FIG. 2.

HELOPELTIS (Larva).

[Much Enlarged Side View]

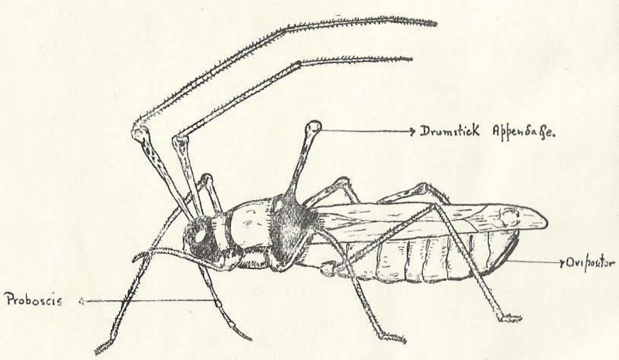

FIG. 3.

HELOPELTIS (Adult Female).

[Much Enlarged Side View.]

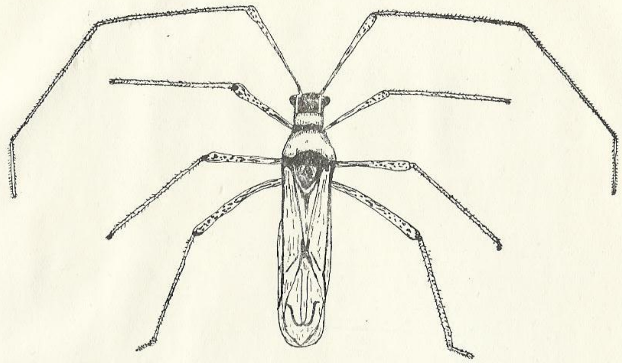

FIG. 4.
HELOPELTIS (Adult).
(Much Enlarged Upper Side View).

FIG. 5.
EUPHORUS HELOPELTIS. (Ferriere).
[Wasp Parasitic on Helopeltis spp.]

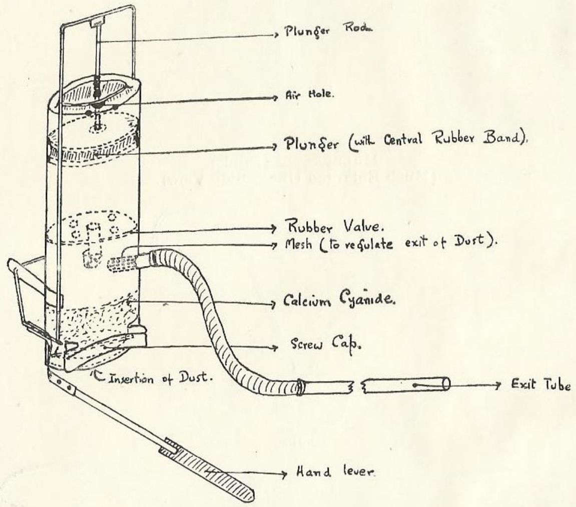

FIG. 6.
KNAPSACK DUSTER

OBSERVATIONS ON HELOPELTIS (TEA MOSQUITO BLIGHT)

FOR

South Indian Tea Planters

Helopeltis spp. are representatives of the capsid family, one of the divisions of the Hemiptera. Included in the Hemiptera order are many pests of the tea plant, which are of very great economic importance. There are a number of species of Helopeltis which are more or less specific to the particular crop to which they adapt themselves. The two members of particular importance to the tea industry are H. Antonii and H. Theivora; the differentiation of these two is by no means easy, for they possess no really significant morphological feature by means of which they may be distinguished. This matter from the aspect of control, however, is not of vital importance and it is sufficient to know that we are dealing with a Helopeltis species.

In the following paragraphs, I propose presenting a brief account of the history of the pest; its distribution in South India; its life history as related to its control and a detailed description of the experiments carried out with calcium cyanide in an attempt to find an appropriate insecticide for dealing with the pest directly.

History of the Pest

From the available literature it would seem that the disease was first noted in Java as early as 1847. It was not attributed to an insect agency and was termed 'Roest' or 'Rust', no doubt owing to the discolorations produced on the leaves attacked.

In Assam, it was first mentioned in 1868 in a Report of Commissioners appointed to enquire into the State and Prospects of Tea Cultivation in Assam, Cachar, and Sylhet. At this time the disease was referred to as 'Blight' and this accounts for the disease caused by Helopeltis being termed 'Tea Mosquito Blight'.

Dr. Anderson, in 1869, seems to have been the first to suggest that an insect was the prime cause of the discolorations on the leaves, but he failed to discover the correct insect responsible for the damage. About the same time, Dr. Alleyboom in Java also came to the conclusion that an insect was the perpetrator of the damage, but he also failed to give the insect its name.

In 1873, Mr. Peal gave a description of Helopeltis but was unable to give it its scientific name. To Mr. Peal, however, remains the credit of having been the first to discover the correct insect causing the damage previously known as 'Rust' and 'Blight' in Java and North-East India respectively. Mr. Moore, from specimens furnished by Mr. Peal, was able to identify the insect as a species of Helopeltis.

In Ceylon, the pest has been known for about forty years on tea, though in 1884, Dr. Trimen recorded it as a serious pest of cocoa and cinchona. A description, however, of Helopeltis Antonii had been made as early as 1858 by a French Entomologist named Signoret.

There is nothing in the current literature to indicate when the pest first made its depredations felt in South India. There cannot be any doubt but that Peermade first felt the seriousness of the pest, though South Travancore must have been a very close second.

It would seem therefore that the two species of Helopeltis of most importance in tea culture, viz., H. Theivora and H. Antonii are indigenous to the tropical and subtropical zones of Java, Sumatra, North-East India, South India and Ceylon.

Distribution of Helopeltis in South India

Helopeltis in South India seems to confine its activities almost entirely to those districts south of, and including, Central Travancore. Watt and Mann divided the tea districts of North-East India into compartments depending upon the seriousness of Helopeltis attacks experienced in those districts. This scheme may also be done for South India as follows:—

(*a*) *Districts where the disease is serious.*—Central Travancore and South Travancore, including the Vandiperiyar, Peermade, Venture Valley, and Poonmudi areas.

(*b*) *Districts where the disease is known but not serious.*—The Wynaads and Mundakayam. Mundakayam is a district situated in the badly stricken area of South Travancore, but the attacks of Helopeltis have only recently been noted. This is probably due to the comparatively young age of the tea.

(*c*) *Districts where the disease is not known on tea.*—Kanan Devans, Anamallais, Nilgiris and North Mysore.

It is very possible that this division will not be a permanent one. Until the last two or three years every district with the exception of Central and South Travancore might have been relegated to Division (*c*). Definite evidence of the presence of

the insect in the Wynaad was found in 1926, and only as recently as the late months of 1927 and early 1928 have queries been received from the Mundakayam district with reference to the identity and nature of an attack of Helopeltis. Insects received from the Mundakayam district were immediately identified as Helopeltis. The Anamallais, with the attitude of its tea estates ranging for the greater part from 3,000 feet to 4,000 feet above sea level, might be expected not to be completely immune from the attacks of Helopeltis, but up to date no evidence of attacks on the tea has been obtained. It is stated that the cinchona in the Anamallais is subject to slight attacks, and that the tea in the neighbourhood might be seen with an occasional bite on its leaves, but apart from this the tea seems to be entirely free. This may not be so always, for the tea on the Anamallais is also comparatively young and attacks from Helopeltis may arrive without the slightest warning and catch the unwary Planter unprepared. This may seem to indicate a tendency towards pessimism, but to this writer of the article it seems much more desirable to ensure that Planters will be in a position to recognize the possibility of danger, and at the same time be in a position to take whatever precautionary measures are available, before the pest has been permitted to gain a stronghold in areas at present free from the pest.

Another interesting correlation may be made between the altitude of districts and the incidence of Helopeltis in South India. Thus estates in Central and South Travancore in the main have an altitude about 3,000 feet or less, above sea level. In these districts, Helopeltis is serious. Estates in the Wynaad range in the neighbourhood of 3,000 feet with a few possible exceptions, and though the pest is present in this district, its ravages

are not felt to any alarming degree. Above this altitude, Helopeltis appears to be absent,—hence its entire absence in the Nilgiris and the Kanan Devans. The comparative absence of the pest on Tea in the Mundakayam district, with its estates situated only at very small altitudes might be explained by the fact that it is only of recent years that tea has been grown in this district; it is further known that almost invariably Helopeltis does not become a serious pest until the tea is in the neighbourhood of fifteen to twenty years of age.

Life History of Helopeltis Spp. as related to Control

The following are some details in the life History of Helopeltis, determined by investigators in North India, amongst whom Antram must receive particular mention.

(*a*) *Eggs.*—The eggs of Helopeltis are deposited by the female adult in the tissue of the plant (see Fig. 1). They are white in colour when deposited, becoming yellowish just prior to the emergence of the insect. They are very slender, tubular shaped and rounded at the ends into the shape of sausage; the size of the eggs is extremely minute, about 1/32" in length. Attached to the end of the egg along the long axis are two hairlike excrescences whose function is not clearly understood. They protrude through the outer layer of the tissue in which the egg is embedded. By means of these hairs, which represent the only external portion of the eggs, the position of the eggs may be recognized.

The eggs represent the most important, and at the same time the most unapproachable, factor in the control of the pest. In fact owing to their characteristic embedment in the tissue the eggs maintain an impregnable position against attacks from

predatory insects and ovicides. The hairlike protuberances seem to assist in the resistance of the eggs against the latter mode of attacking the pest. As a result of this, no attempts, as far as the available literature on Helopeltis proceeds, have been made to control the pest by direct attack on the eggs, and it must be admitted, such attempts could hardly be expected to be attended with success.

Naturally one means suggests itself as likely to eliminate the eggs, viz., the plucking of the shoots in which the eggs are laid. This has been attempted but without success, for the insect need not confine itself to laying its eggs in the flush. Flushing of the bush is also retarded by this procedure and indiscriminate plucking must have a serious effect on the health of the bush, a factor which bears an extremely important relation in the control of any plant disease or pest.

(*b*) *Period of hatching of the eggs.*—This is an extremely variable quantity and depends entirely upon the climatic conditions. These have not as yet been worked out under South Indian conditions but the following table represents the periods determined in North India :—

TABLE I

Month	Period for egg to hatch
January	24 days
February	18 ,,
March	12 ,,
April	9 ,,
May	9 ,,
June	6 ,,
July	6 ,,
August	6 ,,
September	6 ,,
October	9 ,,
November	12 ,,
December	18 ,,

A correlation of these figures, combined with the climatic conditions existing in North India throughout the year, with the climatic conditions existing in the areas attacked by Helopeltis might be expected to throw some light on the period of hatching in South India. Such a deduction was made for the purpose of the experiments with calcium cyanide (q.v.)

The climate in North India may be divided into two clearly defined periods—a dry, cold period, and a hot, humid period. The former lasts from the beginning of December to the end of February, the latter from May to September, the months of October and November acting as the transition period between the hot and cold periods, and March and April as the transition period between the hot and cold periods. The rainfall in North India coincides with the period of maximum heat, so that between April and September we have the maximum temperatures combined with the heaviest rainfall (see Table II), and hence the degree of humidity is highest during this period.

Humidity and heat are the two factors most intimately bound up in the development of Helopeltis individuals, and as a result the attacks of this pest in North India commence to be felt in May, reaching a maximum in July and August.

In the South Indian areas attacked by Helopeltis we find a different set of climatic conditions. In the following table I have given average figures for various climatic conditions for the Dooars (the district in Assam probably most affected by Helopeltis) and those taken on Munjamullai Estate in South India, for comparison.